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G3N

(54) Electronic control device for a drive system

(57) Components (64,68,48) of the drive system e.g. in a vehicle which are to be tested are connectable by way of two circuit paths to a microcomputer (44). The one circuit path serves for the control and testing of the components in the normal operating state, i.e. in the dynamic state with the parts rotating. The other path serves for the monitoring of the same components for defects in the static state with the parts of the drive system stationary and includes for this purpose a switch network (54), a current/voltage source (92) controlled by the microcomputer and an analog-to-digital converter (56). Additionally, a priority control circuit (60) is provided by means of which program interruption demands or demands for switching over to an emergency program in the event of the occurrence of defects are fed immediately or after a delay period to the microcomputer (44).

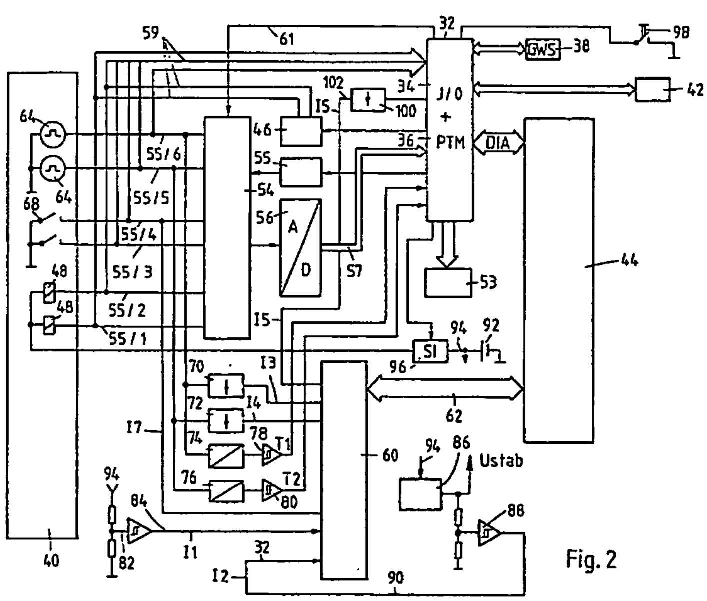

Fig. 2

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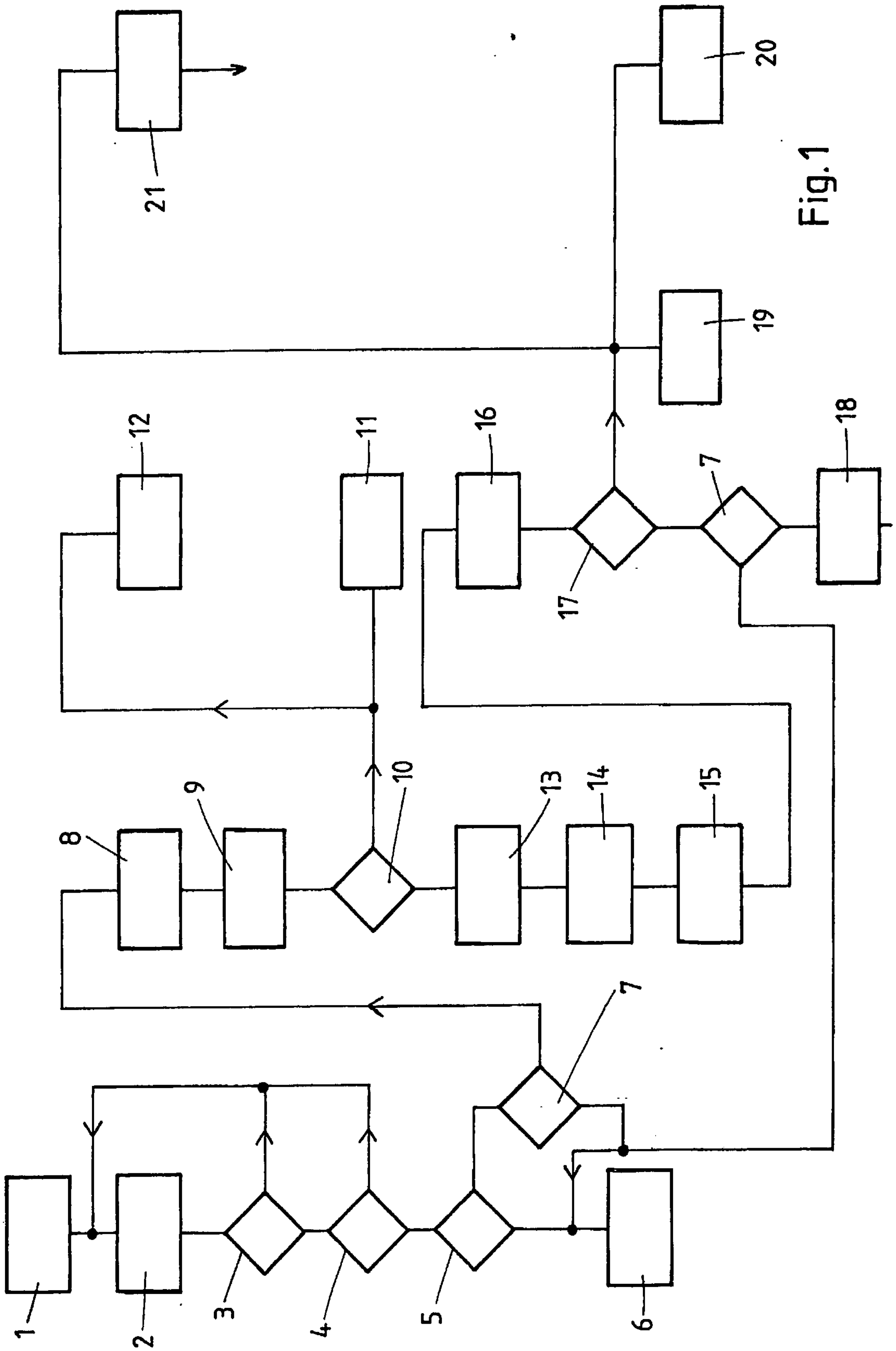

Fig.1

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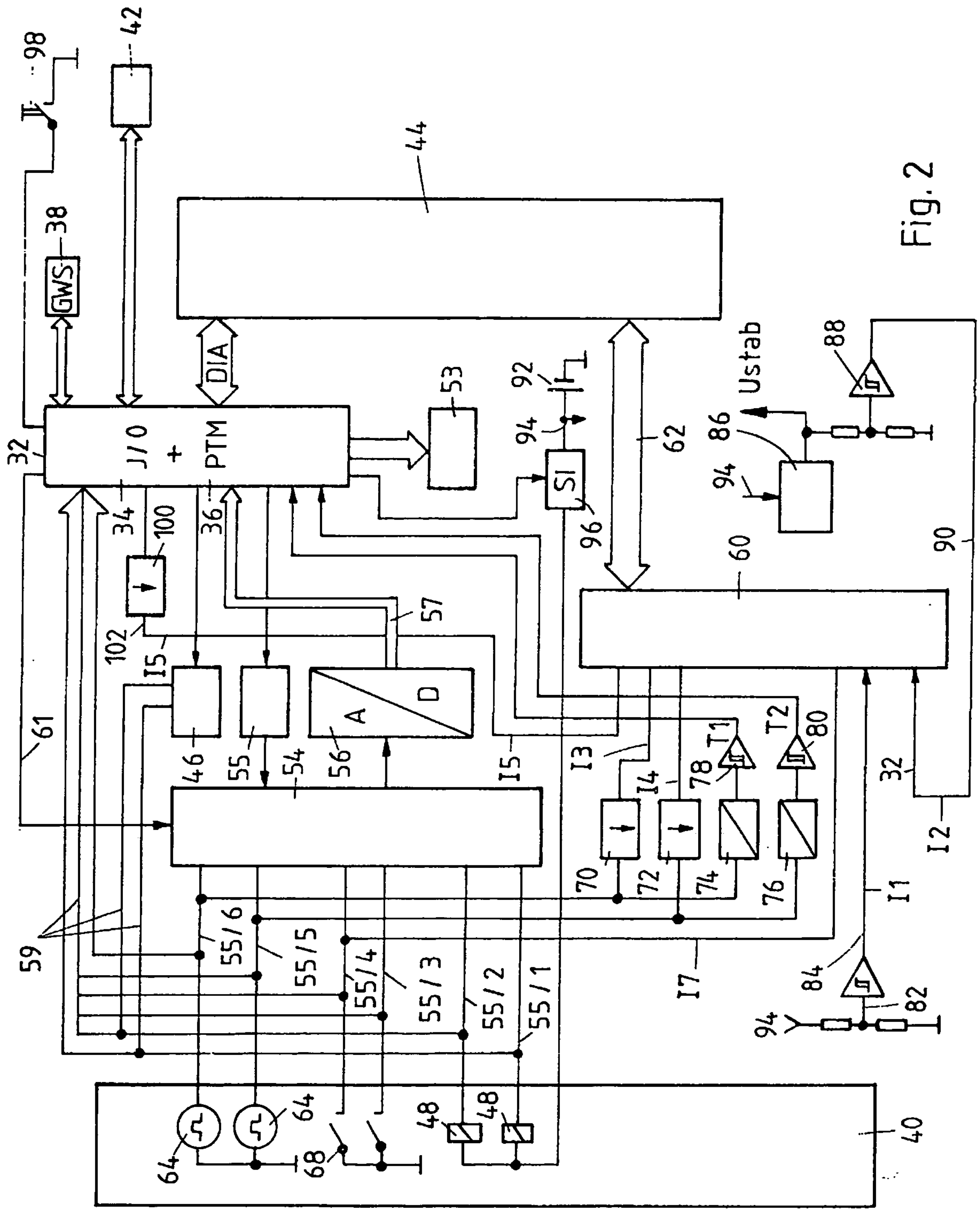

Fig. 2

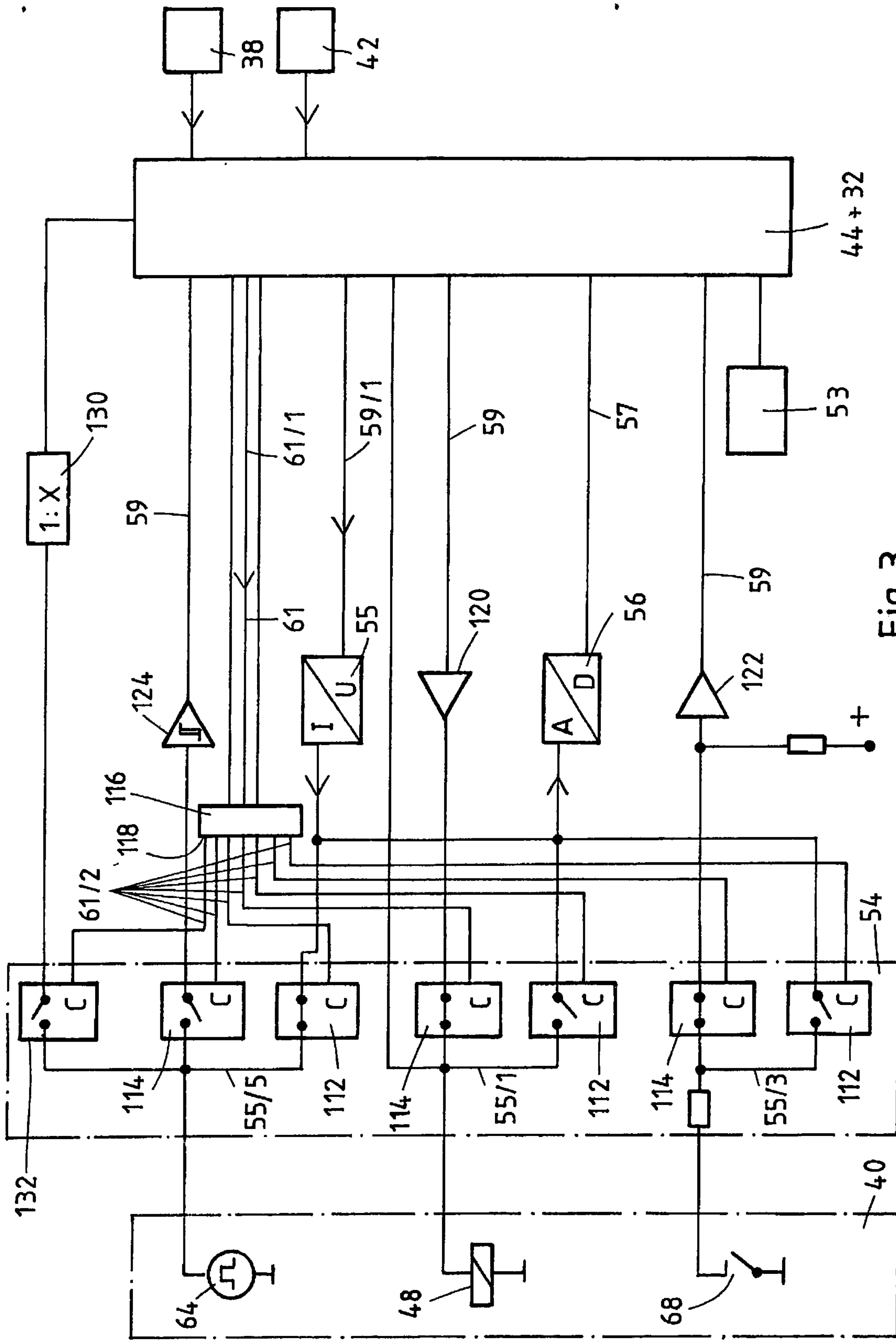
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Fig. 3

SPECIFICATION

Electronic control device for a drive system

This invention relates to an electronic control device for a drive system, particularly of vehicles, comprising a microcomputer which interacts with electrical components of the drive system.

One such control device is known from published West German Patent Application DE-OS 29 33 527.

It is an object of the present invention to prevent accidents and damage arising from technical failure. Thus, it is an object of the present invention to provide a control device which not only monitors the magnitude of faults but which also simultaneously takes measures which, in the event of a defect, prevent damage to parts of the drive system. The control device of the present invention should also preferably enable the source of trouble to be located and possibly also enable statistics about the frequency of particular faults at particular fault locations to be determined automatically.

One or more of these objects are achieved in accordance with the present invention in that a protective device is provided which is connected to the microcomputer and which with an operating voltage switched on reacts to a standstill of rotatable parts of the drive system, in which with a detected standstill of one such part at least some of the electrical components are electrically interrogated according to specific values and in dependence on the results of this interrogation either an emergency program or the normal operating program is started for the control of the drive system, and in which, preferably, the protective device interrogates the components also in the dynamic state according to specific values, and in dependence on the results thereof, upon the occurrence of a defect, interrupts the operating program and starts an emergency program.

The present invention has the advantage that accidents and damage to the drive system due to technical failures are reduced. The invention provides for a checking of electrical components not only in the dynamic state when parts of the drive system are rotating, but also in the static state when the parts of the drive system are stationary. Faults can be located and determined statistically. The components may be tachometers and elements producing signals dependent upon speeds of rotation, switches, relays, pressure-measuring instruments, temperature-measuring instruments, and the like.

A "drive system" within the meaning of the present invention is to be understood as including not only a speed-change gear system per se but also, additionally to the gear system, an associated motor or engine.

In order that the invention may be fully understood a number of embodiments of control device in accordance with the invention will now be described in detail by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a flow diagram illustrating the mode of operation of a control device in accordance with the present invention;

Figure 2 is a block schematic diagram of a first embodiment of electronic control device arranged to operate in accordance with the procedure illustrated in Figure 1; and,

Figure 3 is a block schematic circuit diagram of a modified embodiment of control device in accordance with the invention.

There will first be described the basic mode of operation and functioning of the control device of the present invention.

The invention provides for an automatic checking of electrical components of the drive system, not only in the dynamic state when the parts are rotating, but especially also in the static state when the parts are stationary, i.e. in the case of a vehicle, when the speed-change gear is stationary and the engine is switched off. In both cases however there is this automatic checking only if the operating voltage is available, which in the case of a vehicle can be designed as the on-board voltage. Furthermore, according to the invention, there exists the facility for carrying out a self-test procedure in respect of the electronic control device and its protective device, by means of which faults in these devices themselves can be determined. The static state, in which the gear speed is zero and the engine speed is also zero, is recognised according to the invention by a program interruption demand which is triggered by the components which are being monitored. A microcomputer contains a main program, a normal operating program, which may be part of the main program, sub-programs, to which a "test routine" sub-program also belongs, and one or more emergency programs.

When entering into the test routine in the aforementioned static state, there is carried out first of all a self-test of the electronics of the control device and in particular of its protective device part, and then after this the individual electrical components are checked. In the case of a defect, for example in a pulse transmitter, a magnet, a pressure switch, a temperature switch or the like, the test routine is aborted and an emergency program is started up which then controls the drive system instead of the normal operating program.

The invention will now be described in more detail with reference to the flow diagram shown in Figure 1. Reference numeral 1 signifies the starting up of the control device by switching on the operating voltage, in the case of a vehicle by switching on the on-board voltage. In this way the control device is automatically set up in an initial condition which can be referred to as "auto-reset". Reference numeral 2 indicates checking of the operating voltage UB and checking of a stabilised voltage US, which is necessary for a microcomputer. Reference numeral 3 indicates the decision as to whether UB lies within specific limit values, for example

18V< UB< 32V. If the value of the operating voltage UB lies outside permissible limit values, then a repeat procedure follows. If the value of the operating voltage UB lies within the permitted limits, then there follows at 4 a decision as to whether the stabilised voltage US lies within specific limits, for example 4.8V< US< 5.2V. If this is not the case, then a repeat procedure follows. If the stabilised voltage US lies within the permitted limit values, then there follows at 5 an examination as to whether the vehicle speed is equal to zero, i.e. V=0 km/h. This can be carried out for example by arranging that a tachometer has the value I3=1.

If the condition at 5 is not fulfilled, i.e. vehicle speed positive, then there follows through the normal operating program of the microcomputer the normal control of the drive system, for example by maintaining the current gear by an automatic shifting up or shifting down of the gears. The transfer to the operating program is represented in Figure 1 at 6. If the condition is fulfilled at 5, i.e. vehicle speed zero, then one can check whether the engine is stationary, i.e. whether the engine speed nMOT = 0, corresponding to a value I4=1 of a tachometer. If the condition I4=1 nMOT = 0 is not fulfilled at 7, then there follows a return to the operating program 6. If the condition is fulfilled at 7, then a "test routine" sub-program is initiated at 8.

Thereafter there follows first of all a self-test of the electronic control device, particularly its protective device, according to the symbol 9. This means that the device first of all examines itself to check whether it is in order.

The decision about this is represented by the symbol 10. If the device is not in order, a fault indication is produced according to symbol 11, and, according to symbol 12, an emergency program is initiated by the main program. The emergency program can for example switch off the automatic aspect of the gear system of the drive system, or switch over to manual operation, or switch out a defective gear in the gear system, or switch over to another gear, or block a gear change, or the like.

If the decision at 10 is that the electronic device is in order, then there begins, through the test routine, the interrogation of the individual components of the drive system. For example, according to symbol 13, a gear switching magnet of the gear system of the drive system can be checked. For this purpose, according to symbol 14, a current/voltage source is switched by the test routine to "current". This means that the source operates as a source of current and supplies a constant current *I* which is independent of voltage changes. If on the other hand the programmable source is switched to "voltage", then the source supplies a constant voltage U which is independent of the current consumption *I*. The "test routine" sub-program switches the current/voltage source to current or voltage according to the type of component which is to be checked. According to symbol 15 a test lead for the electrical component to be checked, here for example an input switching magnet, can be switched into circuit. Furthermore, according to symbol 16, with this test routine, specific measurement values can be measured, for example the voltage across the gear switching magnets. In this way it is thus possible to check through the gear switching magnets of all the gears in succession.

According to symbol 17 there then follows a decision as to whether the measured value R1 of the checked component, in the present case as an example the gear switching magnets, lies within predetermined tolerances. If this is the case, then another component can be checked, for example the voltage R2 of a gear switching magnet on the second gear, which is represented in Figure 1 by the symbol 18. Further components to be checked can be measuring and testing points for determining gear-wheel temperatures, gear-wheel defects, bearing temperatures, oil pressure, speeds of rotation and the like.

Before each next component is checked according to symbol 18, there is a renewed checking, as an intermediate step in accordance with symbol 7, as to whether the engine speed is still zero, i.e. whether nMOT = 0. If the condition nMOT = 0 is not fulfilled at 7, then there is a return to the main and operating program 6. If the condition is fulfilled at 7, then the measured value R2 of the next component is determined according to symbol 18.

If the decision at 17 results in a determination that the measured value, e.g. R1 or R2, of a checked component does not lie within the permitted tolerances, then there follows a fault indication 19, the data is stored for statistical purposes according to symbol 20, and the main program initiates an emergency program according to symbol 21. This emergency program can cause the automatic nature of the gear system to be disabled, or only allow continued travel under manual gear control, or only allow continued movement in a particular gear, or the like.

In the embodiment of the invention which is described with reference to Figure 1, the function of the control device is divided essentially into four sections, namely an operating state check according to symbols 1 to 7, a self-test procedure according to symbols 8 to 12, the actual checking of the electrical components of the drive system according to symbols 13 to 18, and the measures to be carried out in response to the results of the checking procedure according to symbols 12, 19, 20 and 21.

One particular embodiment of a control device according to the invention will now be described with reference to the block schematic circuit diagram shown in Figure 2. This control device is suitable for the checking of complete drive systems, i.e. of an engine and its mechanical gearing, by measurement of the electrical and electronic components, such as for example gear switching magnets, switches, speedometers, temperature and pressure gauges and the like, both in the dynamic and in particular also in the static state.

One unit 32 incorporates both an input/output module, hereinafter referred to as an I/O-module 34, and also a programmable timer module, hereinafter referred to as a PTM-module 36. The I/O-module 34 feeds to a microcomputer 44 the electrical data from a gear-selection switch 38, a gear system 40, and also the data from an engine 42, the latter information being obtainable by monitoring specific positions of the accelerator pedal for the engine. Additionally, the I/O-module 34 feeds data from the microcomputer 44 by way of power

amplifiers 46 and over connecting leads 59 to electromagnets 48 which in the present case are for example gear switching magnets of valves for switching the individual gears of the gear system 40. The gear switching magnets 48 are components which are checked by the device of the present invention. The final power stages 46 are amplifier circuits which are necessary since the magnet valves 48 need a higher current than can be supplied by the I/O-module 34. The I/O-module 34 and the PTM-module 36 of the unit 32 are connected together by way of input leads and output leads which are not shown. Further operating leads 59 connect to the microcompurter 44 by way of the unit 32 other electrical components 64, e.g. tachometers, which are to be checked, and yet further such components 68 which may be switches arranged to respond to temperature or pressure.

An alpha-numeric indicating instrument 53 connected to the I/O- and PTM-module unit 32 indicates the important process data.

Test leads 55/1 to 55/6 are connected to that same side of the components 48, 64 and 68 to which the operating leads 59 are connected.

A switch network 54 contains a plurality of switches arranged in the test leads 55/1, 55/6, these switches preferably being analog switches and which serve for the switching over of the components 48, 64 and 68 to be checked to an analog-to-digital converter 56 (hereinafter referred to as A/D converter 56) for monitoring and testing purposes during a test routine. The A/D converter 56 converts the analog measured values of the monitored components by way of the switch network 54 into digital signals which are fed to the I/O-unit 32. The digital output of the A/D converter 56 is connected by way of leads 57 to the unit 32. This unit 32 is in data exchange communication with the microcomputer 44 by way of data and address lines 58. The analog switches of the switch network 54 are selectively controlled by the microcomputer 44 over leads 61, of which only one is shown symbolically, so that the analog switches can be selectively switched in order to test one or more particular components 48, 64 and 68.

A priority control circuit 60 is in data exchange communication with the microcomputer 44 by way of data and address lines 62 and has the object of interrupting, either immediately or after a delay, the running program of the microcomputer 44 in dependence upon the priority of a program interruption demand which arises. The "running program" can be the normal operating program for the control of the drive system running in the dynamic or static operational state of the drive system, or can be an emergency program. The priority control circuit 60 is a conventional component in computer technology. It operates in such a way that in the event of simultaneously occurring interruption demands, one preferred demand is indicated to the microcomputer 44. If an interruption demand has already been given to the microcomputer, and thereafter a higher priority interruption demand arises at the priority control circuit, then the earlier process in the microcomputer 44, e.g. an initiated emergency program, triggered by the lower priority demand, is interrupted and the higher priority demand is fulfilled first.

A program interruption demand with specific priorities can be:

I1 = operating voltage outside permissible tolerances

I2 = stabilised voltage outside permissible tolerances

I3 = inactive condition or failure of a tachometer 64 which monitors the engine speed, or engine speed = 0

I4 = inactive condition or failure of another tachometer 64 which monitors the gear speed, or gear speed = 0

I5 = notice of an error in the program run of the microcomputer

I6 = notice of defects of further signal transmitters 68 for monitoring for example the oil pressure, the temperature, and mechanical errors in the gearing 40 or in components interacting therewith.

All signals from the components 48, 64 and 68 which are monitored go to the switch network 54. Additionally, the signals I3 and I4 of the tachometer 64 go by way of retriggerable monostable sweep circuits 70 and 72 to the priority control circuit 60. The monostable sweep stages 70 and 72 serve to identify whether the gear system 40 and its engine 42 are in the static state (stationary) or whether their parts are rotating. The monostable sweep stages 70 and 72 switch through only if pulses come from the tachometer 64, and lengthen these pulses; while the sweep stages first then decay if no further pulses are received within a specified time period.

The tachometers 64 emit signals corresponding to their speeds of rotation, by way of the operating leads 59 and the I/O- and PTM-unit 32, to the microcomputer 44 which, by means of the gear switching magnets 48, switches to a particular gear of the gear system 40 in dependence upon the measured speed of rotation. Simultaneously, the tachometers 64 emit signals corresponding to the measured speed of rotation, by way of frequency-to-voltage converters 74 and 76 (hereinafter referred to as F/S-converters) and subsequent Schmitt trigger circuits 78 and 80, to the I/O- and PTM-unit 32, and from this unit to the microcomputer 44. The Schmitt trigger circuits 78 and 80 emit a signal T1 or signal T2 by way of the unit 32 to the

microcomputer 44 only in the event of a specified maximum value or a specified minimum value. The signals T1 and T2 correspond respectively to specified desired states of a particular gear in the gear system. The microcomputer 44 compares this desired state with the actual active real state of the gear system 40. By means of the output signals T1 and T2 from the Schmitt trigger circuits 78 and 80 the gear system gears are thus controlled in the dynamic state. For each gear in the system there is provided a gear switching magnet 48 and by way of an F/S-converter 74 or 76 a Schmitt trigger circuit 78 or 80. If the desired value differs from the actual value, then the microcomputer 44 first asks for further criteria, for example whether the vehicle and the gear system have been braked, or whether an emergency signal has been produced by the engine, or the like. If this is not the case, then the difference between the desired value and the actual value does not originate from external factors occurring outside the drive system, and so the microcomputer begins an emergency program. The emergency program can be such that the automatic gear selection of the gear system is rendered inoperative and the gear system can only then be driven for example in second gear, or the like.

In the procedures described above the microcomputer 44, by way of the PTM-module 36, compares the states at the outputs of the Schmitt trigger circuits 78 and 80, having regard to the particular setting of the gear selection switch 38, with the electrical signals of the power amplifier stages 46. If the measured value of the PTM-module 36, plus or minus a permissible programmed tolerance, does not correspond to the output state of the Schmitt trigger circuits, then the current supply from an operating voltage source 92 to the gear switching magnets 48 can be interrupted by a safety circuit 96, which corresponds to an emergency program, or else the current supply is maintained and an appropriate alternative emergency program is initiated. The safety circuit 96 is controlled by the I/O-module 34. What type of emergency program is inititated depends upon the mechanical construction and other properties of the relevant automatic gear system 40. From the outputs of the power amplifier stages 46 there is a feedback to the I/O-module 34 by way of the operating leads 59, whereby switch states of the gear switching magnets which are not permissible can be detected and, as a result of this, the current supply to the gear switching magnets can be switched off.

A circuit 82 is provided which comprises a voltage divider 81, which is connected by way of a lead 94 to the operating voltage source 92, and a Schmitt trigger circuit 83. The circuit 82 supplies a signal indicating "operating voltage in order" or "operating voltage not in order" to the priority control circuit 60 by way of a lead 84. If the operating voltage is not in order, then the priority control circuit 60 reports this fact to the microcomputer 44 which then immediately begins an emergency program. A stabilising circuit 86 connected to the operating voltage source 92 supplies a stabilised voltage Ustab and also supplies to the priority control circuit 60 by way of a window comparator 88 and its output lead 90 a signal indicating "stabilised voltage in order" or "stabilised voltage not in order". If the stabilised voltage is not in order, then this fact is reported by the priority control circuit 60 to the microcomputer 44 which then starts an emergency program.

The part of the control device of Figure 2 which functions as a protective device can be selectively switched in or switched out by means of a switch 98 on the unit 92. In the state where it is switched in, the device works continuously, corresponding to the procedure shown in Figure 1.

A re-triggerable mono-flop circuit 100 (it could alternatively be a flip-flop circuit) is controlled by the microcomputer 44 by way of the I/O-module 32 continuously in defined time intervals by trigger signals so that from the output 102 of the circuit 100 there arises a specific signal not interrupted by the priority control circuit 60, so long as the normal operating program functions in a trouble-free manner. The trigger signals are produced by the normal operating program of the microcomputer 44. Upon the occurrence of a fault in the program run, the trigger signals disappear and at the output 102 of the mono-flop circuit 100 there is produced a program fault signal I5 to the priority control circuit 60. The latter in consequence sends an interruption demand signal to the microcomputer 44. Consequently, the running operating program is interrupted by the microcomputer 44 and the microcomputer 44 is set to a defined starting setting. This starting setting may be the start address of the normal operating program or the start address of an emergency program. Moreover, the safety circuit 96 is triggered by the microcomputer 44.

Figure 3 shows a further embodiment of protective device according to the invention for monitoring components of the drive system both in the dynamic state (while travelling) and also in the static state (stationary). In Figure 3 those parts which correspond functionally to parts shown in Figure 2 are shown with the same reference numbers respectively as in Figure 2. Figure 3 shows a component in the form of a tachometer 64 which produces signals on its test lead 55/5 corresponding to the speed of rotation of the gear system 40 or of the engine 42. A gear switching magnet 48 for switching the gears of the gear system 40 is likewise a component to be checked, and produces on its test lead 55/1 signals corresponding to its particular functional state. A switch 68 may be another component to be checked, in the form of a pressure switch, temperature switch or the like, which produces on its test lead 55/3 a signal corresponding to its particular operational or functional state. The test leads 55/1, 55/3 and 55/5 are each connected to two switches 112 and 114 of the switch network 54. This circuit, just as in the case of Figure 2, is preferably concerned with analog switches which have no direct connection between input and output when the switch is "closed", but which produce at the output an output signal of analog form corresponding to the magnitude of the input signal. The outputs of the switches 112 are connected to the analog input of the analog-to-digital converter 56 and to the output of the current/voltage source 55. The switches 112 are controlled by the microcomputer 44 over the leads 61 and are thereby opened or closed. It will be appreciated from Figure 3 that the unit 32 with its sub-units 34 and 36 shown in Figure 2 has here been integrated into the microcomputer 44. The switches 112

of the switch network 54 are also present in Figure 2, but are not shown there.

Switches 114 are also contained within the switch network in Figure 3. These switches 114 are located in the operating leads 59 and are closed when the switches 112 are open. Conversely, the switches 114 are open when the switches 112 are closed. All the switches 112 and 114 are controlled from the microcomputer 44 over the leads 61. In the leads 61 there is located a decoder 116 which divides the leads into transmission sections 61/1 and 61/2. The decoder 116 functions in such a way that between it and the computer 44 fewer transmission sections 61/1 are necessary than the number of switches 112 and 114. From the output side of the decoder 116 extend as many separate transmission sections 61/2 to the switches 112 and 114 as there are numbers of switches provided. In the operating leads 59 of the gear switching magnet 48 and of the switch 68 are located amplifiers 120 and 122 between the microcomputer 44 and the switches 114 of the switch network 54. In the operating lead 59 of the tachometer 64 there is located, between the switch 114 of the switch network 54 and the microcomputer 44, a Schmitt trigger circuit 124 which produces rectangular pulses for the microcomputer 44 from the substantially sinusoidal pulses from the tachometer 64.

The lead paths which include the switches 112 serve for the checking of the components 48, 64 and 68 in the static state, i.e. with the gear system 40 stationary and possibly also with the engine 42 stationary. The leads 59 which include the other switches 114 of the switch network 54 serve for the checking of the components 48, 64 and 68 in the dynamic state, i.e. with parts of the gear system 40 rotating and also for this purpose to establish whether any parts of the gear system 40 are rotating. The use of switches 114 in the operating leads 59 has the advantage that these leads 59 and the associated part of the microcomputer 44 can be separated by opening the switches 114 from the test circuit containing the switches 112, and thereby their electrical resistance does not falsify the results of the measurement when carrying out the test procedure in the static state.

The device can check itself by carrying out a self-test procedure in the static state; in the static state of the drive system a test signal is transmitted and received again by the microcomputer 44 by way of an operating lead 59 and its amplifier 120, the closed switch 114 of the relevant gear switching magnet 48 and a return lead 59/1. For this, the switch 112 of this gear switching magnet 48 is held open.

For a further self-test of the device in the static state, a test signal of lower frequency is produced in a divider 130 by dividing the crystal-accurate cycle frequency of the clock signal of the microcomputer 44. This test signal is transmitted by way of a switch 132 which is closed in the static state for this self-test procedure and by way of a switch 114 which is likewise closed for this purpose, for example to the component 64, over whose operating lead 59 the signal passes back to the microcomputer 44. Operating faults can be ascertained from this on the basis of changes in the value of the returning signals.

CLAIMS

1. An electronic control device for a drive system, particularly of a vehicle, comprising a microcomputer arranged to interact with electrical components of the drive system, characterised in that a protective device is provided which is connected to the microcomputer and which, when energised by an operating voltage, reacts to a standstill of rotatable parts of the drive system and when a standstill of such a part is detected interrogates at least some of the electrical components electrically according to specific values and in dependence on the results of the interrogation starts either an emergency program or the normal operating program to control the drive system.

2. A control device as claimed in claim 1, in which the protective device monitors the components in the dynamic state also and in dependence thereon, upon the occurrence of a defect, interrupts the operating program and starts an emergency program.

3. A control device as claimed in claim 1 or 2, in which the protective device comprises a switching means by which, with a detected standstill of the drive system and when energised by the operating voltage, the protective device first of all carries out a self-test procedure to establish whether there are defects in the protective device itself before it interrogates the electrical components of the drive system according to specific values.

4. A control device as claimed in any preceding claim, in which the electrical components are each connected to the microcomputer by way of a first electrical path for normal operation and for checking for defects in the dynamic state and also by way of a second electrical path for the interrogation of their specific values in the static state, in which said second electrical paths include switches of a switch network which are controlled by the microcomputer and by means of which a current/voltage source can be connected to the electrical components to be tested, in which the microcomputer, in dependence upon the type of component to be tested, determines whether there is a constant current or a constant voltage at the output of the current/voltage source, and in which there is provided an analog-to-digital converter whose analog input is connected to a connecting point between the current/voltage source and said switches and whose digital output is connected to the microcomputer so that the digital value is proportional to the electrical resistance of the electrical component under test.

5. A control device as claimed in claim 4, in which a second switch of the switch network is arranged in at least one of said first electrical paths, and in which said second switch is closed when the switch in the second path of the same electrical component is opened and vice versa.

6. A control device as claimed in claim 4 or 5, in which at least some of the switches of the switch network are analog switches.

7. A control device as claimed in any preceding claim, in which there is provided a priority control circuit which on the one hand is connected to the electrical components to be monitored and which on the other hand is connected to the microcomputer, the priority control circuit being arranged to interrupt the current running program of the microcomputer immediately or after a delay in dependence on the priority of program interruption demands, wherein these program interruption demands arise from signal values of the tested components which differ from a desired value range and/or from program run errors of the current running program of the microcomputer.

8. A control device as claimed in claim 7, in which electrical components acting as pulse transmitters are connected to the priority control circuit by way of retriggerable monostable sweep stages.

9. A control device according to claim 7 or 8, in which the microcomputer is connected to the priority control circuit by way of a retriggerable monostable sweep stage.

10. A control device as claimed in any preceding claim, in which there is provided an electrical safety circuit which is controlled by the microcomputer and which interrupts the current supply to electrical components formed as gear system control magnets when conditions which are undesirable for the gear system arise.

11. A control device as claimed in any preceding claim, in which electrical components acting as pulse transmitters are connected on the one hand to a programmable timer module of the microcomputer for the digital determination of speeds of rotation and on the other hand are connected by way of frequency-to-voltage converter means with subsequent Schmitt trigger circuits to an input-output unit of the microcomputer, and in which the microcomputer compares the signals from both circuit paths and in the event of a change in the value of the result of this comparison switches over to an emergency program.

12. A control device as claimed in claim 11, in which the switching over to an emergency program prevents or restricts the changing of gears in the drive system.

13. An electronic control device for a drive system substantially as hereinbefore described with reference to Figures 1 and 2 or Figures 1 and 3 of the accompanying drawings.

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